DESIGN HANDBOOK FOR TREE

Chapter 12—Index, Symbols, and Glossary

General Electric Company—TEMPO
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Handbook

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This handbook contains guidelines and data which will be useful to the design engineer when designing electronic systems for survival in a nuclear burst environment. Areas covered in the 12 chapters are the nuclear environment, evaluation of equipment, circuit hardening, system hardening, design tests, hardness assurance, component response data, interaction of transient radiation with matter, and SGEMP. This handbook is concerned primarily with application of hardened electronic devices in hardened circuit design. Physical principles and their application in the development of state-of-the-art devices are included only as required for a better understanding of the data.

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INTRODUCTION

This chapter contains an Index to the subjects presented in Chapters 1, 2, 5, 6, 7, 10, and 11 of this handbook. Subjects are indexed alphabetically according to chapter number and page; e.g., Annealing, 6-9. Also included are a list of Symbols and Abbreviations and a Glossary. These are also arranged alphabetically. The same symbol is sometimes used to represent more than one item. This is clarified by the context in which it is used; e.g., A stands for ampere, altitude, or area, depending on the context. The Glossary has been compiled from a number of sources, and reflects the general concurrence of the community at the time of publication.

When Chapters 3, 4, 8, and 9 are completed, this chapter will be revised. Additions and suggestions for the Index, Symbols, and Glossary that will be helpful to the user are solicited.

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SYMBOLS AND ABBREVIATIONS

A	Ampere
Å	Angstrom
A	Atomic mass number
A	Altitude
A	Area
ABM	Anti-ballistic missile
AF	Annealing factor
ASTM	American Society for Testing and Materials
ATR	Air Transport of Radiation Code
a	Impurity-concentration gradient
a	Acceleration
a	Proportionality constant
a	Junction capacitance measured at contact potential ϕ
ac	Alternating current
B	Proportionality constant
B	Magnetic field
BV	Breakdown voltage
BV_{CBO}	Collector-base breakdown voltage (emitter open)
BV_{EBO}	Emitter-base breakdown voltage (collector open)
BV_{CEO}	Collector-emitter breakdown voltage (base open)
b	Mobility ratio (μ_n/μ_p) in a given material
b	Proportionality constant
C	Speed of sound
C	Confidence level
C	Degree(s) Celsius (centigrade)
C	Capacitance

C_a	Avalanche region capacitance
C_{BE}	Capacitance shunting the external base-emitter resistor, R_{BE}
C_d	Diffusion capacitance of a semiconductor junction
C_g	Gate-to-substrate capacitance
C_i	Emitter-base junction capacitance at total reverse junction potential of 1 volt
C_{ib}	Emitter-base junction capacitance
C_j	Voltage-dependent junction capacitance
C_o	Collector-base junction capacitance at total reverse junction potential of 1 volt
C_o	Zero bias capacitance
C_t	Transistor capacitance
C_{ob}	Collector-base junction capacitance
C_v	Junction capacitance at a total reverse junction potential of 1 volt
C	Proportionality constant
CAD	Computer aided design
CCB	Configuration Control Board
CTF	Circuit tolerance factor
CMOS	Complementary metal-oxide semiconductor
c	Speed of light in a vacuum
c	Proportionality constant
cal	Calorie, a unit of heat or other energy (1 G-calorie = 4.186 joules)
cm	Centimeter
cw	Continuous wave
D	Dose
D_{γ_T}	Total gammas dose from all sources
D_{γ_P}	Prompt gamma dose
D_{γ_s}	Scattered gamma dose
D_{γ_n}	Gamma dose from inelastic scattering and capture of neutrons
$D_{\gamma_{fp}}$	Gamma dose from fission products
D	Diffusion constant
D	Mobile defects
D_p	Average electron penetration depth
$\dot{D}$	Dose rate
D(E)	Damage equivalence

DTL	Diode-transistor logic
d	Constant
d	Half-width of diode-base region
db	Decibel
dc	Direct current
E	Energy
E_B	Migration energy barrier
E_d	Displacement energy
E_n	Neutron energy
E_p	Energy loss per ion pair, primary energy
E_R	Recoil energy
E_t	Threshold energy
E	Electric field
E_γ	Gamma efficiency
EB	Electron beam
ECL	Emitter-coupled logic
ECP	Engineering change proposal
E_i	Ionization potential
EMP	Electromagnetic pulse
e	Electron
e	Charge on an electron
eV	Electron volt
F	Force
F	Proportionality constant
F	Gain-bandwidth product in charge-controlled model
F	Farad
F	Thermal yield fraction
F(u)	Planck energy distribution $\frac{15}{\pi^4} \frac{u^3}{e^u - 1}$
FBR	Fast-burst reactor
FET	Field-effect transistor
F(H)	Burst height adjustment factor
FXR	Flash x-ray
f	Frequency

f	Occupation probability of radiation-induced traps
f_γ	Fraction of burst yield emitted as prompt gamma
f_x	Fraction of burst yield emitted as prompt x-rays
f_T	Transistor gain-bandwidth product, the frequency at which $h_{fe} = 1$
f_α	Common-base cutoff frequency of a transistor, the frequency at which the magnitude of α is reduced to 0.707 times its low-frequency value
$f(\Omega)$	Angular factor
G	Conductance
GTO	Gate-turn-off switch, a silicon-controlled rectifier with gate-turn-off capability
Gy	Gray (1 Gy = 100 rads)
g	Carrier-generation rate per unit volume
g	Gram
g	Gravitational acceleration
H	Henry
H	Magnetic field
HA	Hardness assurance
HADD	Hardness assurance design documentation
HCI	Hardness critical item
HI-REL	High-reliability
HM	Hardness maintenance
HOB	Height of burst
HS	Hardness surveillance
Hz	Hertz
h	Altitude
h_{FB}	Transistor, common-base, static forward current transfer ratio
h_{FE}	Transistor, common-emitter, static forward current transfer ratio
h_{fb}	Transistor short-circuit, common-base, small-signal forward current transfer ratio
h_{fe}	Transistor short-circuit, common-emitter, small-signal forward current transfer ratio
$h\nu$	Photon energy
I	Current
I_A	SCR anode current
I_B	Base current
I_C	Collector current
I_C	SCR cathode current

I_{CO}	Collector leakage current
I_{CS}	Collector saturation current
I_{CS}	Collector-substrate current
I_D	Drain current
I_{DIFF}	Diffusion current
I_E	Emitter current
I_{ES}	Emitter saturation current
I_G	SCR gate current
I_{pp}	Peak primary photocurrent
I_{SC}	Short-circuit current
I_S	Surface current
I_S	Solar cell short-circuit current
I_T	Threshold current
I_V	Gunn diode current
i	Ideal diode current
i_{pp}	Primary photocurrent; in transistors, the collector-base primary photocurrent
i_{pps}	Primary photocurrent across the substrate collector junction in integrated circuits
i_{ppe}	Emitter photocurrent
i_{pD}	Drain-to-substrate junction photocurrent in irradiated MOS transistor
i_{pG}	Gate displacement current in irradiated MOS transistor
IC	Integrated circuit
IGFET	Insulated gate field effect transistor
I^2L	Integrated injection logic
I_o	Thermal yield partition
$I_o(E)$	Source intensity as function of energy
J	Joule
JEDEC	Joint electronic devices engineering council
JFET	Junction field effect transistor
J_e	Emission current density
J_n	Electron current density
J_p	Hole current density
JI	Junction isolated
K	Degrees Kelvin

K	Lifetime damage constant
K′	Composite damage constant
K″	Composite damage constant
K_c	Carrier removal constant
K_d	Proportionality constant used in calculating the charge in delayed capacitor conductivity
K_g	Carriers generated per unit volume per unit of exposure
K_n	Neutron damage constant
K_p	Proportionality constant used in calculating the charge in prompt capacitor conductivity
K_L	Minority-carrier diffusion-length damage constant
K_V	Volume damage introduction
K_μ	Neutron mobility damage constant
K_τ	Lifetime damage constant
KT	Effective blackbody radiating temperature
k	Carrier-removal damage constant
k	Boltzmann's constant [1.380×10^{-23} J/(molecule · K)]
k	Energy-dependent carrier-generation constant
k	Proportionality constant
keV	Thousand electron volts
kg	Kilogram
km	Kilometer
kt	Kiloton
kW	Kilowatt
kΩ	Kilohm
L	Length
L	Diffusion length
L_o	Initial diffusion length
L_n	Electron diffusion length
L_p	Hole diffusion length
L	Inductance
L_s	Tunnel diode equivalent inductance
LED	Light emitting diode
LINAC	Linear accelerator

LS	Life-cycle survivability
LSI	Large scale integration
LSP	Life-cycle survivability program
M	Mass
M	Emission constant
MeV	Million electron volts
MIL-STD	Military Standard
MIS	Metal-insulator semiconductor
MJ	Megajoule
MOS	Metal-oxide semiconductor
MOSFET	Metal-oxide-semiconductor field-effect transistor
MSI	Medium scale integration
MW	Megawatt
MΩ	Megohm
m	Mass
m	Meter
mA	Milliampere
mg	Milligram
mH	Millihenry
min	Minute
mm	Millimeter
msec	Millisecond
mV	Millivolt
mW	Milliwatt
N	Number
N	Mobile defect concentration
N	Neutron dose
N	Avogadro's number $[6.25 \times 10^{23}/(g \cdot mole)]$
N	Junction grading constant
N	Proportionality constant
N_a	Density of target atoms
N_d	Number of unannealed displaced atoms
N_t	Available trap concentration

N(E)	Normalized gamma spectral distribution
n	Neutron
n	Electron concentration
n_e	Number of primary electrons per unit area
n_p	Photons per unit area
n_p	Gamma photon fluence
nsec	Nanosecond
P	Pressure
P	Power dissipation
P_F	Probability of failure
P_S	Probability of survival
$\dot{P}_{E_\gamma}$	Peak prompt-gamma energy-emission rate
PC	Printed circuit
PCB	Printed circuit board
PMOS	p-channel metal-oxide semiconductor
P-I-N	A semiconductor structure with highly doped P and N regions on two sides of a relatively pure region
p	Hole concentration
p	Proton
pF	Picofarad
p_o	Thermal equilibrium hole concentration
Q	Radiant (thermal) exposure incident on a receiver
Q	Charge
Q	Energy deposition
q	Electronic charge (1.60×10^{-19} coulombs)
q_e	Electronic charge (1.60×10^{-19} coulombs)
QA	Quality assurance
QAB	Quality Assurance Board
QAP	Quality assurance program
QC	Quality control
R	Range
R	Roentgen
R	Reflectivity in solar cells
R	Resistance

R_e	Electron range
R_f	Fireball radius
R_s	Adjusted slant range
Rad (material)	Deposited dose in (material)
RDT&E	Research Development Test and Engineering
RV	Reentry vehicle
rf	Radio frequency
S	Neutron source strength
SCD	System control document
SCR	Silicon controlled rectifier
SDM	Supplier data monitoring
SEM	Scanning electron microscope
SGEMP	System generated electromagnetic pulse
SOP	Standard operating procedures
SOS	Silicon on sapphire
SOW	Statement of work
SPO	System project officer
SPRF	Sandia Pulse Reactor Facility
SSI	Small scale integration
S/V	Survivability/vulnerability
STTL	Schottky transistor-transistor logic
sec	Second
T	Absolute temperature
T_A	Air transmission factor
T_B	Transmission coefficient for blackbody temperature of interest
T_{BI}	Base time constant, inverted configuration
T_{BN}	Base time constant, normal configuration
T_{CI}	Collector time constant, inverted configuration
T_{CN}	Collector time constant, normal configuration
T_H	Haze transmission factor
TLD	Thermoluminescent detector
TTL	Transistor-transistor logic
t	Time

t_n	Time of neutron arrival
t_p	Radiation-pulse width
t_r	Rise time
t_s	Electrical storage time
t_{sr}	Radiation storage time, the time a transistor remains in saturation after termination of the radiation pulse
t_x	X-ray emission time
t_γ	Prompt gamma ray full pulse width at half maximum
t	Thickness
UGT	Underground test
u	$\frac{\partial v}{\partial t}$
u	Particle velocity
V	Volt
V	Voltage
V_{BE}	Transistor base-emitter voltage
V_{CC}	Collector supply voltage
V_{CE}	Transistor collector-emitter voltage
$V_{CE(SAT)}$	Transistor collector-emitter saturation voltage
V_{CB}	Transistor collector-base voltage
V_{DD}	Drain supply voltage
V_{FB}	SCR forward breakover voltage
V_G	Gate voltage of MOS transistor
V_T	Threshold voltage
V_j	Effective applied junction voltage
V_Z	Junction contact potential
VLSI	Very large scale integration
v_n	Thermal velocity
W	Total weapon yield
W	Watt
W	Width
w	Width of junction or space-charge region
X	X-ray fluence
$\dot{X}$	X-ray flux

x	Thickness of material
Y	Total yield
Y_e	Effective spectral yield (thermal)
Y_F	Fission yield
Y_x	Total x-ray yield
Y_γ	Prompt gamma yield
y_f	Forward quantum efficiency
y_r	Reverse quantum efficiency
Z	Impedance
Z	Atomic number
Z_m	Molecular charge number
α	Alpha particle
α	Initial spectral attenuation coefficient
α	Transistor short-circuit common-base current gain
α	Absorption coefficient
β	Short range absorption modification factor
β	Ratio of electron velocity to speed of light
β	Transistor short-circuit common-emitter current gain
β_o	Initial value of β
β_Φ	Value of β after neutron fluence Φ
γ	Constant
γ	Gamma
γ	Dose rate (material)
$\dot{\gamma}$	Dose rate [rads (material)/sec]
$\dot{\gamma}_p$	Prompt gamma dose rate
Δ	Change in value
ΔP	Overpressure or dynamic pressure
$\Delta\sigma$	Excess bulk conductivity
ϵ	Permittivity
ϵ_o	Free space permittivity
θ	Angle
θ	Slope of log I versus V curve
κ	Dielectric constant

λ	Lattice constant
μ	Majority carrier mobility
$\mu(E)$	Mass absorption coefficient
μ_c	Compton absorption coefficient
$\bar{\mu}_\gamma$	Normalized gamma dose coefficient
$\bar{\mu}_x$	Normalized x-ray energy fluence coefficient
μA	Microampere
μF	Microfarad
μH	Microhenry
μsec	Microsecond
μV	Microvolt
μW	Microwatt
ν	Frequency
ν	Photon frequency
ν_o	Atomic vibrational frequency
ρ	Density
ρ	Air density
ρ	Resistivity
$\bar{\rho}$	Average air density
$\bar{\rho}_a$	Average air density for thermal applications
ρ_o	Sea level air density
ρ_o	Initial resistivity
ρ_t	$0.0026\ Y^{-0.5} gm/cm^3$
ρ_Φ	Resistivity after neutron fluence Φ
σ	Cross section
σ	Conductivity
σ_i	Ionization cross section
σ_{n_o}	Capture cross section
τ	Time constant
τ	Lifetime
τ_h	High-level, minority-carrier lifetime
τ_n	Effective lifetime of electrons
τ_{no}	Free carrier lifetime

τ_o	Initial minority-carrier lifetime
τ_p	Effective lifetime of holes
τ_s	Electrical storage time constant
τ_Φ	Minority-carrier lifetime following a neutron fluence, Φ
Φ	Fluence
Φ	Neutron fluence
Φ_n	Neutron fluence
Φ_o	Photon flux entering material
Φ_x	X-ray energy fluence
Φ_γ	Gamma ray energy fluence
ϕ	Flux
ϕ	Neutron flux
ϕ	Photon flux
ϕ	Neutron spectrum
ϕ	Junction contact potential
ϕ_e	Electron flux
ω	Radian frequency, $\omega = 2\pi f$
Ω	Ohm

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GLOSSARY

Absorbed dose – See Dose.

Absorbed-dose rate – See Dose rate.

Air ionization current – Photocurrent generated by radiation ionizing the air.

Alpha (α) – Transistor short-circuit, common-base current gain.

Alpha particle – Subatomic particle with a +2 charge. Basically a helium atom with two orbital electrons stripped away, but with the nucleus of two protons and two neutrons. With its positive charge, it causes ionization by pulling electrons out of their orbits.

Avalanche multiplication – A process whereby free-charge carriers are accelerated by an electric field to sufficient energies that, upon collision with an atom, additional charge carriers are produced by ionization.

Beta (β) – Transistor short-circuit, common-emitter current gain (h_{FE}).

Beta particle – An electron identical to the electrons that orbit the nucleus of an atom, except that it originates in the nucleus of the atom. Range of a beta particle is about 20 feet in air. With its negative charge, it causes ionization by repelling, or pushing, electrons out of their orbits.

Blackbody – A perfect emitter (radiator) of electromagnetic radiation having a characteristic temperature which is the sole determinant of its radiated energy spectrum.

Bremsstrahlung – German for "radiation resulting from a stopping process" or, literally, "from braking." Designates electromagnetic radiation generated when high-energy charged particles are accelerated (or decelerated) by electric or magnetic fields. Usually, bremsstrahlung is generated by the interaction of an electron beam with the nuclear Coulomb field of the atoms in a target material. The cross section for this interaction increases strongly for electron energies above 1 MeV. The bremsstrahlung energy spectrum is continuous and ranges from zero up to the maximum energy of the incident particles.

Charge-carrier generation – The formation of ions which are then available for the conduction of current in semiconductors is referred to as hole-electron pair generation.

Charge emission currents – The flow of current generated by the departure of electrons from a material.

Charge transfer – A term commonly applied to the movement of charge within a material or from one material to another due to the interaction of high-energy nuclear radiation (gamma rays, x-rays, neutrons) with the material(s).

Circumvention – A general term applied to techniques which, when a system is temporarily perturbed by a radiation pulse, enable the system to recognize the cause of the perturbations and to ignore any misinformation generated by them.

Clamping – A technique by which the excursion of a voltage or current within a circuit is limited through the use of additional components; sometimes employed as a circuit-hardening technique.

Compensation – A general category of techniques employed to divert primary and secondary photocurrents or to nullify their effects as an aid to circuit hardening against ionizing radiation.

Compton effect, Compton scattering, or Compton process – The collision of a photon with a free electron that produces a second photon of lower energy and a recoil electron.

Compton electron – An orbital electron of an atom that has been ejected from its orbit and possesses a momentum as a result of its interaction with a high-energy photon.

Cut-off region – The device operating region (state) such that there is essentially zero current flow from or into the device terminals.

Damage threshold – That minimum influence of radiation which changes one or more material or device properties significantly.

Dark current – A current that flows in photoemissive and photoconductive detectors when there is no radiant flux incident upon the electrodes. The dark current may vary considerably with temperature.

Delayed gamma rays – Gamma ray resulting from scattering and radioactive decay spread over a period of time which is long compared to that in which the prompt radiation is produced.

Delayed neutrons – Neutrons from the fission process, emitted an appreciable time after the moment of fission. Certain isotopes created in the fission process (fission products) decay with a half-life less than one minute to daughter products which are in an excited state and which instantaneously decay by neutron emission.

Depletion-mode transistor – A field-effect transistor that is quiescently "on" or conductive at zero gate bias.

Diffusion – The movement from regions of high concentration to regions of low concentration.

Diffusion length – The average distance which minority carriers will diffuse through a crystal lattice between generation and recombination.

Dopant – A material added to a semiconductor to supply electrical carriers.

Dose – The radiation energy absorbed per unit mass of a material, or the time-integrated absorbed-dose rate [Unit: rad (material)].

Dose rate – The radiation energy absorbed per unit time and mass by a given material [Unit: rad (material)/s)].

Drain – The ohmic contact in an FET device from which the majority carriers are removed.

Electron emission – The departure of electrons from a material.

Electron injection – The transport of electrons from one medium to another, e.g., across junctions, barriers, and transition regions in semiconductors, or across metal-dielectric interfaces.

Enhancement-mode transistor – A field-effect transistor that is quiescently "off" or nonconductive at zero bias.

Epitaxial – Refers to the formation of single-crystalline material upon a single-crystalline substrate by chemical reduction from the vapor phase. The grown material assumes the same crystal orientation as the substrate.

Exposure – ". . . The quotient of ΔQ by Δm, where ΔQ is the sum of the electrical charges on all the ions of one sign produced in air when all the electrons (negatrons and positrons) liberated by photons in a volume element of air, whose mass is Δm, are completely stopped in air . . ." Here Δ refers to an increment small enough so that ". . . a further reduction in its size would not appreciably change the measured value . . . and, on the other hand, is still large enough to contain many interactions and be traversed by many particles" [Unit: R]. In certain contexts the dictionary definition of exposure is implied.

Exposure rate – ". . . the quotient of ΔX by Δt, where ΔX is the increment in exposure in time Δt . . ." and Δ has the meaning outlined in Exposure above [Unit: R/s].

Failure threshold – That dose which changes one or more material (device) properties to such an extent that the material (device) becomes unsuitable for a specified application.

Fluence – The number of particles or photons or the amount of energy that enters an imaginary sphere of unit cross-sectional area. The time-integrated flux.

Flux – The flow of photons, particles, or energy per unit time through an imaginary sphere of unit cross-sectional area.

Forbidden energy gap – Energy interval between allowed energy bands in a solid, especially between the valence and conduction bands in semiconductors and insulators.

Gamma rays – Highly penetrating, high-frequency electromagnetic radiation from the nuclei of radioactive substances. They are of the same nature as x-rays, but of nuclear rather than atomic origin, and are emitted with discrete, definite energies, $E = h\nu$. (In many references, a distinction between gamma rays and x-rays is not made.)

Hole – The absence of an electron in the electronic valence structure of a semiconductor that acts as a positive electronic charge with a positive mass.

Inelastic scattering – Scattering in which the kinetic energy of a two-particle system is decreased, and one or both of the particles is left in an excited state.

Ionization – The separation of a normally electrically neutral atom or molecule into electrically charged components.

Ionizing radiation – Electromagnetic radiation (gamma rays or x-rays) or particle radiation (neutrons, electrons, etc.) capable of producing ions, i.e., electrically charged atoms or molecules, in its passage through matter.

Latchup – Regenerative device action in multilayer integrated circuit structures in which an undesired stable condition is attained.

Linear accelerator (LINAC) – A device in which charged particles are accelerated along a straight line. A machine for producing a high-intensity beam of high-energy electrons or bremsstrahlung that can be used as a laboratory source for the study of ionizing-radiation effects.

Majority carrier – In semiconductors, the type of carrier that constitutes more than half the total number of carriers. The majority carriers are electrons in an n-type semiconductor and holes in a p-type semiconductor.

Minority carrier – The type of carrier that constitutes less than half the total number of carriers in a semiconductor. The minority carriers are holes in an n-type semiconductor and electrons in a p-type semiconductor.

Minority carrier lifetime – The average time an excess electron spends in the conduction band of a p-type semiconductor or an excess hole spends in the valence band of an n-type semiconductor.

MOSFET – Metal-oxide semiconductor field-effect transistor.

Neutron – A particle with no electric charge, but with a mass approximately the same as that of the proton. In nature, neutrons are bound in the nucleus of an atom, but they can be knocked out in various kinds of nuclear interactions.

Neutron fluence – Time-integrated neutron flux [Unit: n/cm^2].

Neutron flux – The product of the neutron density (number per cubic centimeter) and the neutron velocity; the flux is expressed as neutrons per square centimeter per second. It is numerically equal to the total number of neutrons passing, in all directions, through a sphere of 1-cm^2 cross-sectional area, per second [Unit: $n/cm^2 \cdot s$].

Neutrons, fast – Neutrons with energies exceeding 10 keV, although sometimes different energy limits are given.

Neutrons, thermal – Neutrons in thermal equilibrium with their surroundings. At room temperature, their mean energy is about 0.025 eV.

N-type – Refers to a semiconductor whose majority carriers are electrons.

Nuclear radiation – Particulate and electromagnetic radiation emitted from atomic nuclei in various nuclear processes.

Nuclide – A nuclear species with a particular mass and charge.

Permanent effects – Changes in material properties that persist for a time long compared with the normal response time of the system of which the material is a part.

Photocurrent – A flow of excess charge carriers generated by ionizing radiation.

Photoelectric (current) – Pertaining to the electric effects of electromagnetic radiation, especially to photoelectric emission, the phenomenon of a material giving off electrons (photoelectrons), manifested by certain metals when subjected to suitable radiation. The movement of these electrons in an electric field imposed for the purpose is a photoelectric current.

Pinch-off region FET – The state of a FET such that the drain-to-source current is essentially independent of the drain-to-source voltage (the saturation region for a FET).

Planar diffused – A technique for manufacturing semiconductor devices by introducing dopant elements into the semiconductor wafers by selective diffusion from the surface.

Planckian spectrum – Blackbody energy spectrum according to Planck's radiation law.

Potting – The complete immersion or encapsulation of devices or circuitry in an insulating compound–used to reduce effects of leakage currents caused by radiation-induced air ionization.

Primary photocurrent – The flow of excess charge carriers across a semiconductor (pn) junction due to ionizing radiation creating electron hole pairs throughout the device. The charges associated with this current are only those produced in the junction depletion region and in the bulk semiconductor material approximately one diffusion length on either side of the depletion region (or to the end of the semiconductor material, whichever is shorter).

Prompt conductivity – Conductivity produced by free carriers generated by ionizing radiation before the carriers are trapped the first time.

Prompt dose – The radiation dose received from the initial radiation pulse of a detonating nuclear weapon.

Prompt gamma radiation – The gamma radiation received from the initial radiation pulses. More precisely, the gamma radiation that originates during the nuclear-device disassembly phase. These gammas are emitted during the peak reaction.

Prompt photocurrent – The photocurrent caused by prompt gamma rays.

P-type – Refers to a semiconductor whose majority carriers are holes.

Pulse width – The length of time the pulse remains above a given value (50 percent of the peak pulse value is often chosen as the given value).

Rad – A unit of absorbed dose equal to 100 ergs of absorbed energy per gram of absorbing material.

Radiation storage time – The time required for excess minority carriers generated by ionizing radiation to recombine and restore the concentration of minority carriers to a level corresponding to the threshold of saturation (the boundary between the active and saturation region in a transistor).

Radioactivity – Spontaneous nuclear disintegration occurring in elements such as radium, uranium, and thorium and in some isotopes of other elements (e.g., ^{60}Co). The process is usually accompanied by the emission of alpha and beta particles or gamma rays.

Recombination – A process by which a hole-electron pair is annihilated, usually by direct combination of a free electron with a free hole, by capture of a free electron by an excited center containing a hole, or by capture of a free hole by an excited center containing an electron. Recombination transitions of these types may be radiative.

Recombination center – A site in a semiconductor at which a free charge carrier may be captured and subsequently recombined with a carrier of opposite polarity.

Replacement current – A current tending to reestablish charge equilibrium after perturbation of the normal charge distribution by radiation.

Rise time – The time required for a signal pulse to rise from 10 to 90 percent of its absolute peak magnitude.

Roentgen – A unit of exposure that produces charge in the amount of 2.58×10^{-4} coulumb/kg (exactly) and is equivalent to a dose of 87.7 ergs per gram in air [0.877 rad (air)].

Saturation region (radiation) – That range of radiation intensities that produces signals in circuitry sufficient to cause electrical saturation of semiconductor components.

Secondary electron – An electron emitted as a result of bombardment of a material by high-energy radiation.

Secondary emission – The emission of secondary electrons.

Secondary photocurrent – The flow of excess charge carriers across a semiconductor pn junction due to ionizing radiation plus any additional charge transfer due to the beta of the transistor.

SGEMP – A term commonly applied to the replacement currents and the electric and magnetic fields generated within a target material by the interaction of high-energy nuclear radiation (gamma rays, x-rays, neutrons) with the target.

Shielding – The technique of enclosing an object within a container specifically designed to attenuate or otherwise exclude nuclear or electromagnetic radiation.

Source – The ohmic contact in an FET where majority carriers enter the device.

Space-charge region – Another name for the depleted region around a pn junction; often referred to as the depletion region because virtually all free charge carriers are swept out of this region.

Spectral-sensitivity characteristic – The relation between the radiant sensitivity and the wavelength of the incident radiation on a camera tube or phototube, under specified conditions of irradiation.

Steady-state photocurrent – The flow of excess charge carriers across a semiconductor junction due to ionizing radiation exposure, when the time duration of the radiation exposure is long compared to the minority-carrier lifetime in all regions of the device.

Storage time – In transistors, the time interval between the cessation of base overdrive and the increase of collector voltage to 10 percent of its final value.

Substrate hogging – A condition in semiconductor integrated circuits with thin collector regions in which photocurrent from the collector divides between the collector-base and collector-substrate junctions, resulting in the reduction of total transistor photocurrent.

Survive – To be able to function within desired specifications after exposure to a nuclear-burst environment.

Total charge – Sum of all the charge removed, added, or transported as the case may be.

Transient effects – Changes in material properties that persist for a time shorter than, or comparable to, the normal response time of the system of which the material is a part.

Transient radiation – The radiation environment produced by a nuclear burst or nuclear-burst simulation facility. The pulse width at half-maximum intensity ranges from nanoseconds to a few milliseconds.

Trapping center – A site in a solid at which a free electron or hole may be captured, and in which the charge carrier, once captured, has a greater probability of being thermally reexcited to a free state than of recombining with a carrier of the opposite sign.

TREES – Transient Radiation Effects on Electronic Systems.

Trigistor – A silicon-controlled rectifier (SCR) with gate-turn-off capability; also called a gate-turn-off switch (GTO).

X-rays – High-frequency electromagnetic radiation produced by any of three processes: (1) radiation from a heated mass (e.g., a blackbody) in accordance with Planck's radiation law; (2) bremsstrahlung; and (3) electron transitions between atomic energy levels, usually excited by incident beams of high-energy particles, resulting in characteristic, discrete energy spectra. (In many references, a distinction between x-rays and gamma rays is not made.)

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